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Diet of olives:
Oliva tigridella Duclos, 1835 in Queensland

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Abstract
Field observations of *Oliva tigridella* in Queensland revealed a diet of small gastropods, bivalves, echinoids and holothurians. Foraging animals were observed carrying prey attached to the rear of the foot. Up to seven prey items were recorded on the foot. Analysis of gut contents showed a high frequency of holothurian spicules although these were rare amongst items found on the foot. This study reveals a previously unrecorded catholic diet of olives although small gastropods and bivalves are important components.

Key words: Gastropoda, Olividae, diet

Introduction
Species of the neogastropod family Olividae are often abundant in shallow water, sandy habitats of the tropics and subtropics. They have many adaptations for sand burrowing - including the shiny, unornamented, cylindrical shell, foot with parapodia and large crescent-shaped propodium and a long siphon. Despite the attention given to the family by shell collectors, little is known of their biology including their feeding habits. Olsson & Crovo (1968) observed the feeding of *Oliva sayana* from Florida in an aquarium, where it took live bivalves, *Donax* and *Laevicardium*, as well as pieces of fish, shrimp and steak and placed them in a pocket at the posterior ventral end of the foot. The gastropod then retreated into the sand and consumed the prey. This foot pocket, or pouch, is a ventral down-folding of the posterior end of the foot and is present in several, perhaps all, *Oliva* species including *Oliva tigridella*, the subject of this paper (Kantor & Tursch, 1998 plates 3 & 7). More is known about the ecology of Olivellidae but species in this family differ significantly in anatomy from Olividae (Kantor, 1991) and likely also in feeding biology. Some olivellid species are known to be deposit feeders (Edwards, 1969; Kantor, 1991), suspension feeders (Seilacher, 1959), predators of foraminiferans (Hickman & Lipps, 1983) and of bivalves (Marcus & Marcus, 1959).

In November 1997, near Cairns, we observed a small population of *Oliva tigridella* foraging across low intertidal sand flats. Closer examination revealed that some of these gastropods were carrying prey in sticky mucus adhering to the posterior of the foot. This observation initiated a three day study (7-9 November 1997) of the population to obtain quantitative data on the natural diet of the gastropod.

Taxonomic note
Oliva tigridella Duclos, 1835 has usually been considered a synonym of *Oliva oliva* (Linnaeus, 1758) which has been regarded as a highly variable taxon but is more likely a complex of several closely similar species (Kantor & Tursch, 1998). However, Tursch & Kantor (unpublished observations) have recently recognised

that the two species differ not only in shell characters but also in penis shape and radular tooth morphology. Many published and museum records of *O. oliva* from Queensland (e.g. Wilson, 1994; Jansen 1996) are likely to be *Oliva tigridella* (pers. comm. B. Tursch).

Methods

The study site was located at the south end of Yorkeys Knob beach, 12 km north of Cairns, Queensland, Australia (145°43' E, 16º48.8' S). *Oliva tigridella* was abundant in an area up to 40-50 m from the base of the beach and protected to the seaward by low sand bars. Standing water of 10-20 cm was retained behind the sand bars at low water spring tides. The substrate comprised uniform medium-coarse quartz sand. Observations were made on 7-9 November on a falling tide between 0630-1100 h each day. Foraging *O. tigridella* were located by following trails and the gastropods examined. Prey were found adhering to the rear of the foot, loosely held in a mucus mass. Normally prey are held in the foot pouch but this is likely to be everted when the animal is handled. The mucus may be important in keeping prey within the pouch. Those carrying prey were measured with calipers in the field, and the prey removed and placed in individual plastic bags for measurement and identification in the laboratory. A sample of 11 *Oliva* was collected for gut content analysis; this sample was boiled soon after collection and preserved in 80% ethanol. These olives were subsequently dissected and food remains extracted from the stomach and rectum. These were mounted on glass slides in "Aquamount" and the items identified from skeletal remains by microscopic examination. Abundance of *Oliva tigridella* was estimated by 50 x 50 cm randomly thrown quadrats with the sand washed through a 2 mm mesh sieve. Voucher material of *Oliva tigridella* is deposited in the collection of the Natural History Museum, London.

Results

Individuals of *Oliva tigridella* were actively foraging on the falling tide from early to mid-morning with trails extending for several metres in length. The olives moved rapidly and occasionally were seen chasing small *Cadella semen* and *Donax verninus*. By mid-morning most olives had ceased foraging and lay buried in the crests of the rippled sand.

A total of 32 quadrats, representing 8m^2, yielded 15 *O. tigridella*, a density of 1.9/m^2. The only other significant macrofaunal animal recorded in the quadrats was the sand dollar *Arachnoides placenta* with a density of 2/m^2.

Sixty-four individual *O. trigridella* (mean shell height 20.4±2.8 mm, range 16.9-30 mm) were located carrying prey with a combined total of 104 prey items (Table 1). The most commonly recorded prey (71% of items) were the small umbonine gastropod *Isanda coronata* (mean height 2.9±0.54 mm) and the tellinoidean bivalve *Cadella semen* (shell length 4.6±1.08 mm) (18.4% of items). Other prey, including small mactrid and donacid bivalves, crustaceans, a juvenile (4.0 mm) echinoid *Arachnoides placenta*, a small holothurian (*Trochodota maculata*), and an echiuroid were much less frequent (Table 1). Most *O. tigridella* (62.5%) carried single prey items (Table 2), 28% had two items, but one carried seven *Isanda*. Usually when *Oliva* was carrying multiple prey items these comprised solely *Isanda* (Table 3). Although *Cadella semen* are larger than *Isanda*, there was no significant difference in the size of *O. tigridella* taking these two prey (mean 20.8 mm versus 20.4 mm). Prey animals carried by *O. tigridella* were found in various stages of consumption. For example, some *Isanda* were intact, others were partially eaten and others had shells empty except for the operculum. This suggests that shelled prey are held in the foot pouch during feeding by the proboscis and not swallowed whole. No predation damage was detected on any of the shelled prey.

Table 1. Prey items recovered from the foot of *Oliva tigridella*.
Total number with food = 64.

	Numbers of prey	Numbers of *Oliva* with prey type	Mean height (mm)	S.dev	Range
Gastropoda					
Isanda coronata Adams, 1854	74	43	2.9	0.54	1.7-4.0
Bivalvia					
Cadella semen (Hanley, 1845)	19	18	4.6	1.08	3.0-6.1
Paphies elongata (Reeve, 1854)	1	1	_	_	6
Notospisula sp.	2	1	_	_	2.9, 3.5
Donax verninus Hedley, 1913	1	1	_	_	2.5
Mactra cf *olorina* Philippi, 1846	1	1	_	_	5
unidentified bivalve fragment	1	1	_	_	_
Crustacea - amphipod	1	1	_	_	_
Crustacea - isopod	1	1	_	_	_
Echiuroida - skin	1	1	_	_	_
Echinoidea					
Arachnoides placenta (L., 1758)	1	1	_	_	_
Holothuroidea					
Trochodota maculata Clark, 1921	1	1	_	_	_
TOTAL PREY	**104**	**71**			
Height of *Oliva tigridella* (n=64)			20.4	2.8	16.9-30.0

Out of eleven animals dissected for gut content analysis, six contained food remains. All six individuals contained spicules (sigmoids and wheels) from the small, chiridotan holothurian *Trochodota maculata* (identified from Cannon & Silver, 1986); additionally, two individuals also contained crustacean fragments, one of these also had vetigastropod radular teeth (probably *Isanda*) and a further *Oliva* also contained setae of a nereid polychaete.

Table 2. Number of prey items held in foot by individual olives.

Number of prey items	1	2	3	4	5	6	7
Oliva with all prey	40	18	2	2	0	1	1
Oliva with *Isanda*	23	12	1	2	0	1	1
Oliva with *Cadella*	16	1	0	0	0	0	0

Table 3. Prey combinations held in foot by individual olives.

	N
Isanda only	40
Cadella only	14
Isanda / *Cadella*	2
Isanda / *Arachnoides*	1
Notospisula / *Paphies*	1
Cadella / *Donax*	1
Cadella / Amphipod	1
Other items	3

Sieving of sand (ca1500 cm^2) for potential prey items in the area where olives were foraging yielded 16 *Isanda*, 2 *Cadella semen*, 1 *Donax verninus*, 2 *Mactra* juveniles and one naticid *Neverita didyma*. Hand sorting of a sand sample of 315 cm^2 yielded one prawn, one *Trochodota maculata*, and one *Isanda*.

Discusssion

Our results for *Oliva tigridella* confirm previous observations (Olsson & Crovo, 1968; Kantor & Tursch, unpublished) that olives capture prey whilst foraging and then store the items in the pouch at the posterior ventral end of the foot. Captured prey are passed to the foot pouch by the proboscis. Feeding on these prey items takes place when the olives are buried in the sand and the varying states of digestion of the shelled prey indicates that the shelled prey, at least, are consumed within the foot pouch rather than being swallowed whole. Smaller, soft-bodied prey may be swallowed entire. Olives have two potential sources of toxic secretions which may be involved in prey capture and immobilization although there have been no direct tests. Choline esters capable of causing paralysis of prey have been have recorded from the hypobranchial gland of seven species of *Oliva* (Roseghini et al. 1996). Additionally, olives possess accessory salivary glands with the ducts opening at the proboscis tip. These glands have a histology similar to those found in Muricidae which have been shown to produce serotonin, a muscle relaxant (West et al. 1994).

The habit of carrying prey in the foot pouch may be a strategy enabling olives to maximise foraging time with the consumption of the food taking place later whilst the olives are buried beneath the sand. Available prey in the habitat, such as *Isanda* and *Cadella*, are probably individually too small to meet the metabolic requirements of the olive and capture of several prey items is needed on each foraging excursion. In our study the *O. tigridella* were foraging in the early morning on a falling tide later becoming buried and quiescent on the incoming tide. Foraging on the surface exposes the olives to risk from predation (crabs, fish) and environmental factors such as heat stress and the consumption of prey beneath the sand can be viewed as a behaviour to minimize this risk.

Species of a few other gastropod families are known to carry prey on their foot; Coleman (1981 p.50) illustrates the volute *Melo miltonis* (Gray, 1834) from southern Australian carrying a captured *Turbo pulcher* in a "tail pouch". Also Branch & Branch (1981 figs 107-9) illustrate *Marginella rosea* capturing a *Gibbula zonata* and attaching it to the posterior tip of the foot "...where it carries it around until hungry." Many Volutidae hold and manipulate large gastropod prey in the foot (Morton, 1986) and the development of the foot pouch for prey carrying in *Oliva* could be a modification of this behaviour for life in unstable sandy substrates.

In conclusion, it should be emphasized that this is a very short term study and there may be seasonal changes in diet. Also the prey collected and identified may be those which take longest to consume and are therefore retained for longer in the foot pouch. This problem is highlighted by the high frequency of holothurian spicules recorded in the gut content samples compared with the single record of a holothurian from the foot pouch. Nevertheless, there is little information available on the diet of any *Oliva* species and the data presented here indicate that although *Oliva tigridella* feeds upon a range of prey species, small gastropods and bivalves and a holothurian are important components of the natural diet.

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References

Branch, G. & Branch, M. 1981. *The Living Shores of Southern Africa*. Cape Town, C. Struik Publishers.

Cannon, L.R.G. & Silver, H. 1986. *Sea cucumbers of Northern Australia*. Brisbane, Queensland Museum.

Coleman, N. 1981. *Shells alive!* Adelaide, Rigby Publishers Limited .

Edwards, D.C. 1968. Reproduction in *Olivella biplicata*. *Veliger* **10:** 197-204.

Hickman, C.S. & Lipps J.H. 1983. Foraminifery: selective ingestion of foraminifera and test alterations produced by the neogastropod *Olivella*. *Journal of Foraminiferal Research* **13:** 108-114.

Jansen, P. 1996. *Common seashells of coastal northern Queensland*. Privately published.

Kantor, Y.I. 1991. On the morphology and relationships of some oliviform gastropods. *Ruthenica* **1:** 17-52.

Kantor, Y.I. & Tursch, B. 1998. *Oliva ouini*, a new species from Hansa Bay, Papua New Guinea, with notes on the anatomy of *O. oliva* (L., 1758). *Apex* **13:** 131-153.

Marcus, E. & Marcus, E. 1959. Studies on Olividae. *Boletin da Facultade de Filosofia. Ciencias e Letias, Universidad de Sao Paulo 232 Zoologia* **22:** 99-188

Morton, B. 1986. The diet and prey capture mechanism of *Melo melo* (Prosobranchia: Volutidae). *Journal of Molluscan Studies* **52:** 156-160.

Olsson, A.A. & Crovo, L.E. 1968. Observations on aquarium specimens of *Oliva sayana* Ravenel. *Veliger* **11:** 31-32.

Roseghini, M., Severini, C., Erspamer, G.F. & Erspamer, V. 1996. Choline esters and biogenic amines in the hypobranchial gland of 55 molluscan species of the neogastropod Muricoidea superfamily. *Toxicon* **34:** 33-55.

Seilacher, A. 1959. Schnecken im Brandungssand. *Natur und Volk* **89:** 539-366.

West, D.J., Andrews, E.B., McVean, A.R., Osborne, D. & Thorndyke, M.C. 1994. Isolation of serotonin from the accessory salivary glands of the marine snail *Nucella lapillus*. *Toxicon* **32:** 1261-1264.

Wilson, B. 1994. *Australian Marine Shells, Part 2*. Kallaroo, Western Australia, Odyssey Publishing.